Assessment of WRF-ARW V3.0 with Pleim-Xiu LSM, Pleim Surface-Layer and ACM2 PBL

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Outline

- Motivation and Background
- Experiment design
- Evaluation
- Summary

Motivation

- Extend capabilities of MM5 to WRF
- Consistent mixing between the meteorological and chemical transport models
- Indirect soil moisture and temperature nudging can improve near-surface meteorology in retrospective simulations for air quality applications
- New LSM and PBL options in WRF

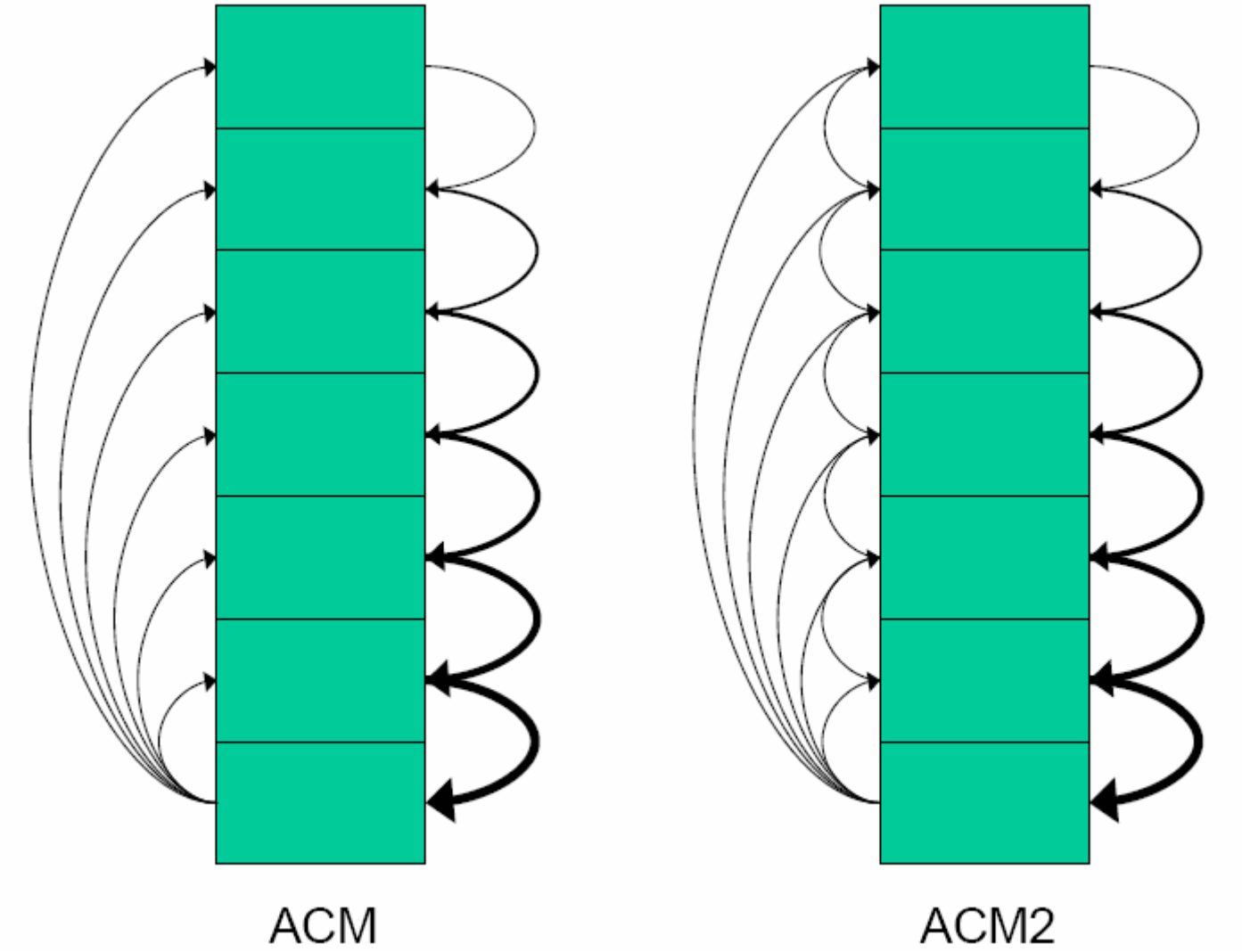
Pleim-Xiu LSM

(Xiu and Pleim, 2001; Pleim and Xiu, 2003)

- Based on ISBA (Noilhan and Planton, 1989)
- 2-layer prognostic soil moisture and temperature
  - surface (1 cm), root zone (1 m)
- Grid cell aggregated surface parameters from fractional landuse and soil type
  - Leverage NLCD
- Indirect soil moisture nudging
- New version (WRFV3) includes deep soil temperature nudging.

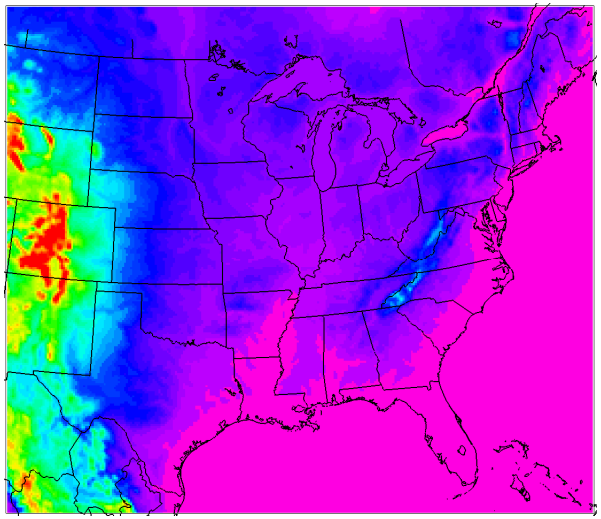
ACM2
(Pleim, 2006; Pleim, 2007a,b)

- Non-local closure scheme (Stull, 1984; Blackadar, 1976; Pleim and Chang, 1992)
- Transilient model for unstable PBL, eddy diffusion for stable PBL.
- Rapid upward transport by buoyant plumes and gradual downward transport by compensatory subsidence
  - asymmetric (ACM) vs. symmetric (e.g., Blackadar)
- ACM2
  - Allows some local mixing at all levels
  - Leads to more continuous profiles in lower layers
  - Smoothes transition from stable to unstable


ACM
ACM2

Simulations

- January and August 2006
- 12 km eastern US
- FDDA (grid)
- IC's and BC's 12km NAM



Land-surface Configuration

RUN ID	LSM	PBL	Surface-layer
WRF PXACM	PX (7)	ACM2 (7)	Pleim (7)
MM5 PXACM	PX (7)	ACM2 (7)	Pleim
WRF NOAHYSU	NOAH (2)	YSU (1)	M-O (1)
WRF NOAHMYJ	NOAH (2)	MYJ (2)	M-O Janic (2)
WRF RUCYSU	RUC (3)	YSU (1)	M-O (1)

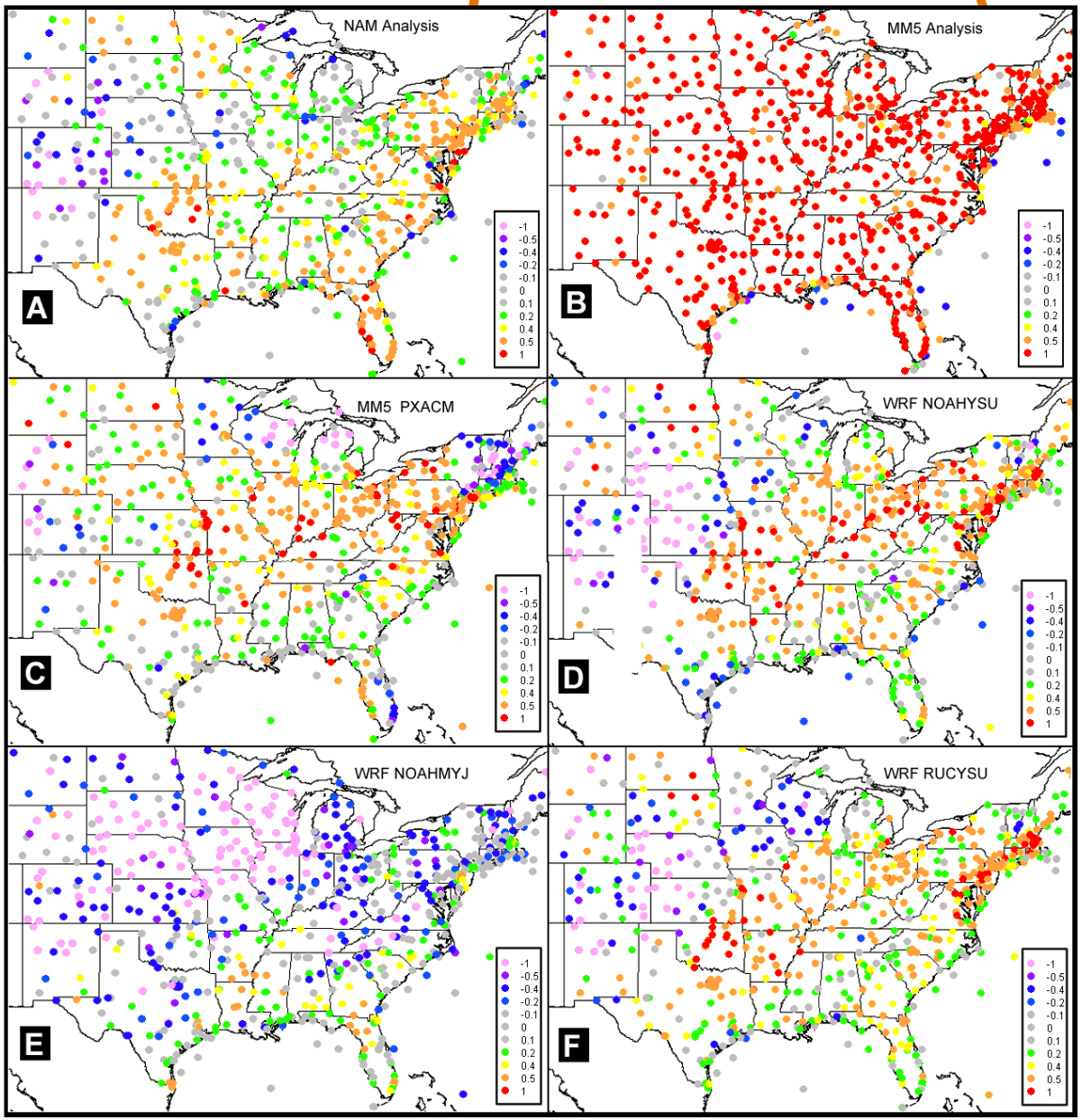
Common Physics

Other Common Configurations	All WRF	MM5
Microphysics	WSM 6-class (6)	Reisner 2 (7)
Convective	Kain-Fritsch 2 (1)	Kain-Fritsch 2 (8)
Shortwave	Dudhia (1)	Dudhia
Longwave	RRTM (1)	RRTM (4)
Initial conditions	NAM-218	NAM-218
Boundary conditions	NAM-218	NAM-218
FDDA driver	NAM-218	NAM-218
Soil moisture nudging	NAM-218	RAWINDS

Performance Assessment

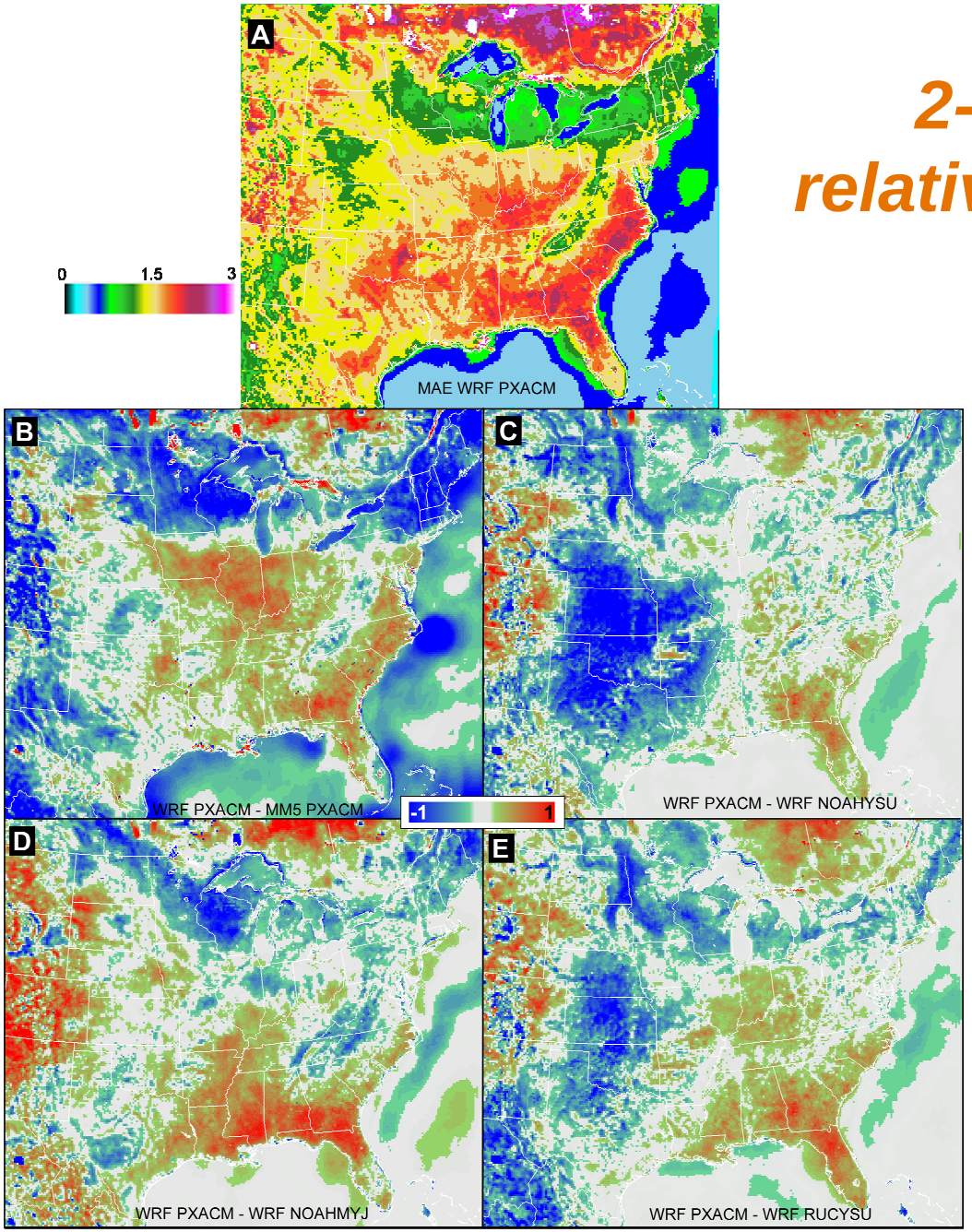
- Surface-based Model – Obs comparisons
- Model – Analysis comparisons
- Precipitation
- Aircraft profile – model comparisons [PX only]

2-m Temperature RMSE (January 2006)



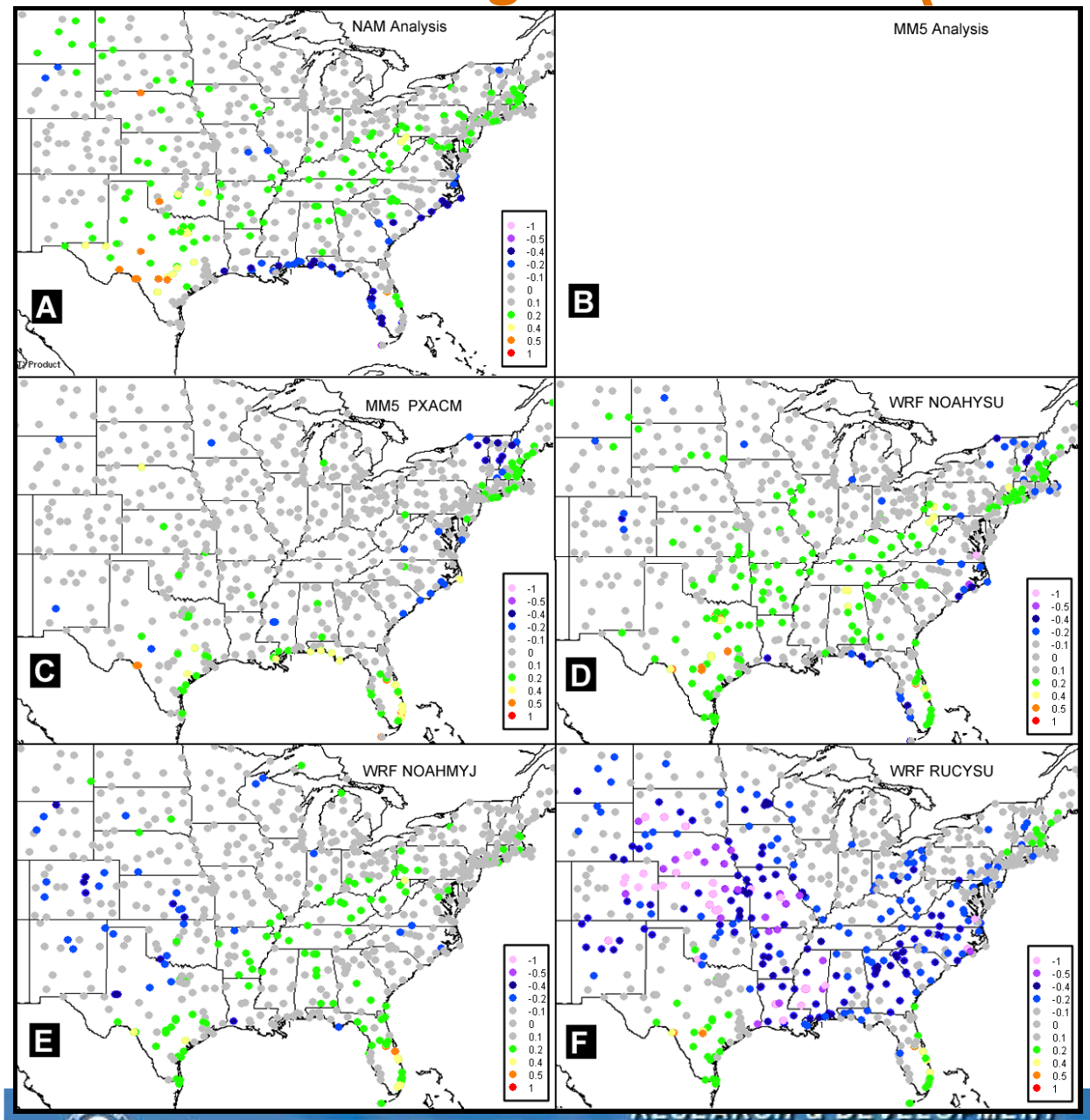
- RMSE of WRF PXACM **minus** other simulations
- NAM analysis more error in western part of domain; significantly less error in east
- RAWINS derived surface analysis has significantly less error everywhere
- MM5 PXACM much less error across Midwest, more error in west and Northeast
- WRF NOAHYSU and RUCYSU much less error across Midwest; more error in western part of domain
- WRF NOAHMYJ more error almost everywhere

2-m Temperature MAE relative to analysis (Jan 2006)



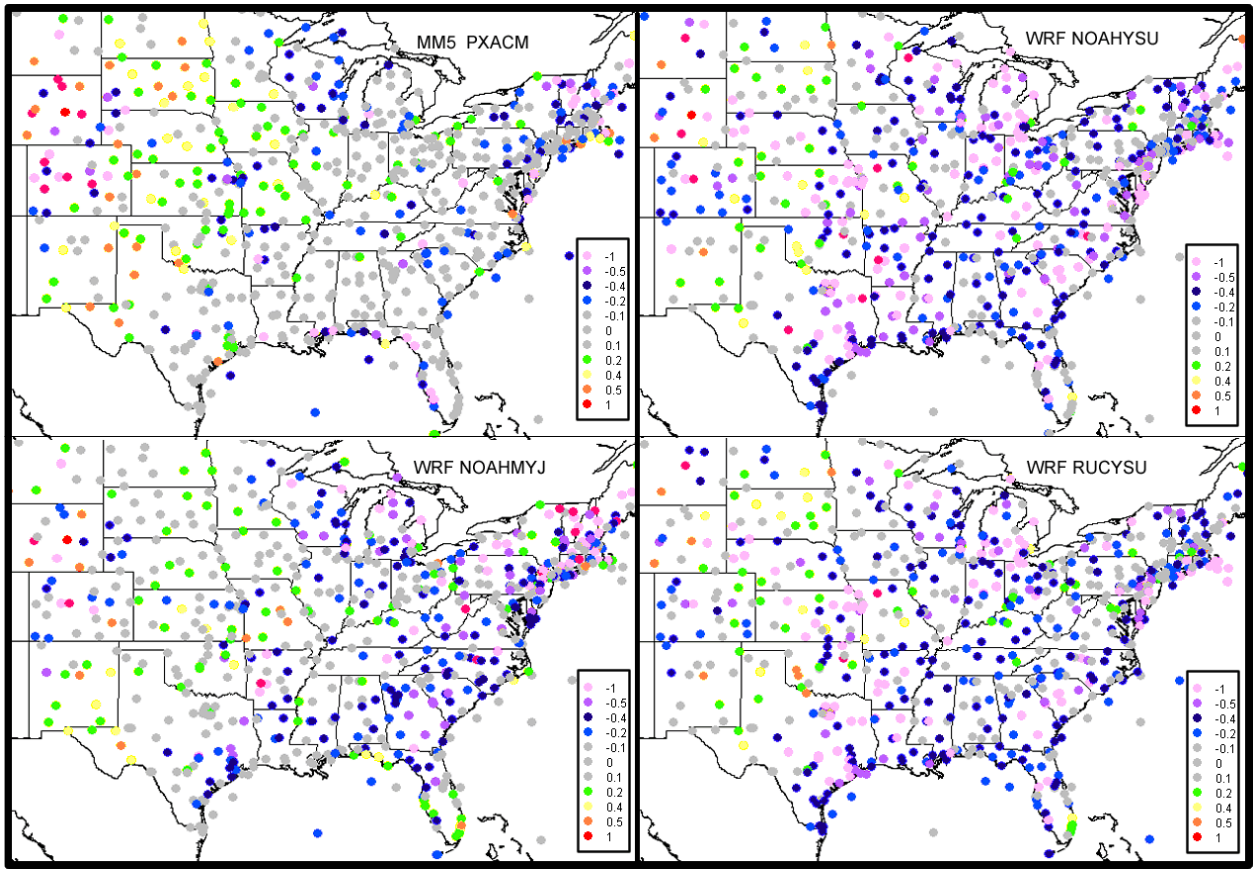
- MAE of WRF PXACM **minus** other simulations
- Large error (> 2 K) over Canada and the southern US, but low error (~ 1 K) across the Great Lakes and Northeast
- MM5 has lower error over the deep south and Midwest, but greater error in areas of the Rockies and Great Lakes
- Other WRF configurations generally have lower error in the Midwest and southeast US, but error in the Plains and northeast US

2-m Mixing Ratio RMSE(January 2006)



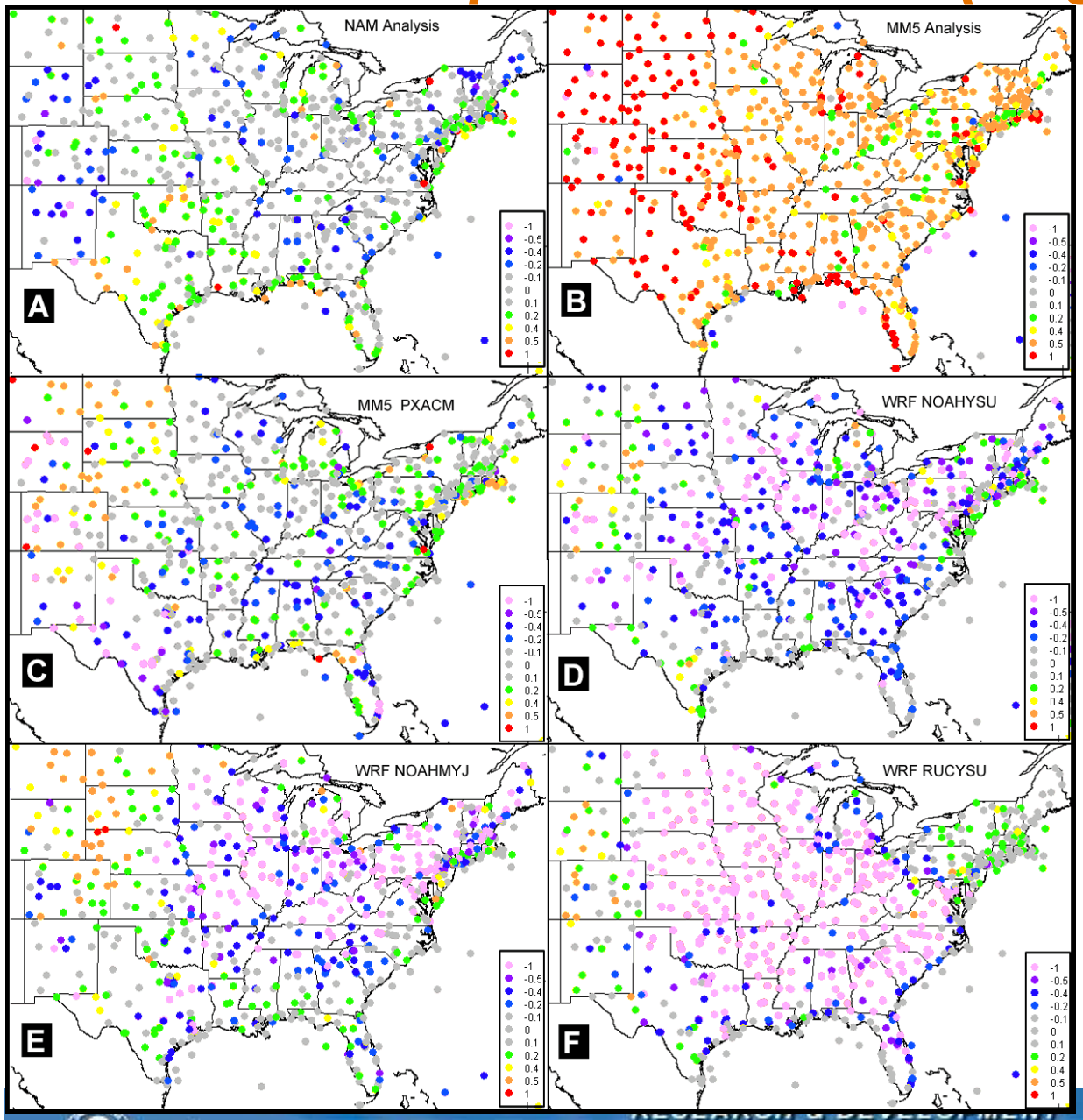
- RMSE of WRF PXACM **minus** other simulations
- Mixing ratio error of WRF PXACM similar to NAM; more error from Tx to Ma, but less along the SE coast
- Little error difference between WRF and MM5 PXACM
- Slightly more WRF PXACM mixing ratio error than the NOAHYSU and NOAHMYJ
- WRF RUCYSU has more error over much of the domain than the PXACM

10-m Wind RMSE(January 2006)



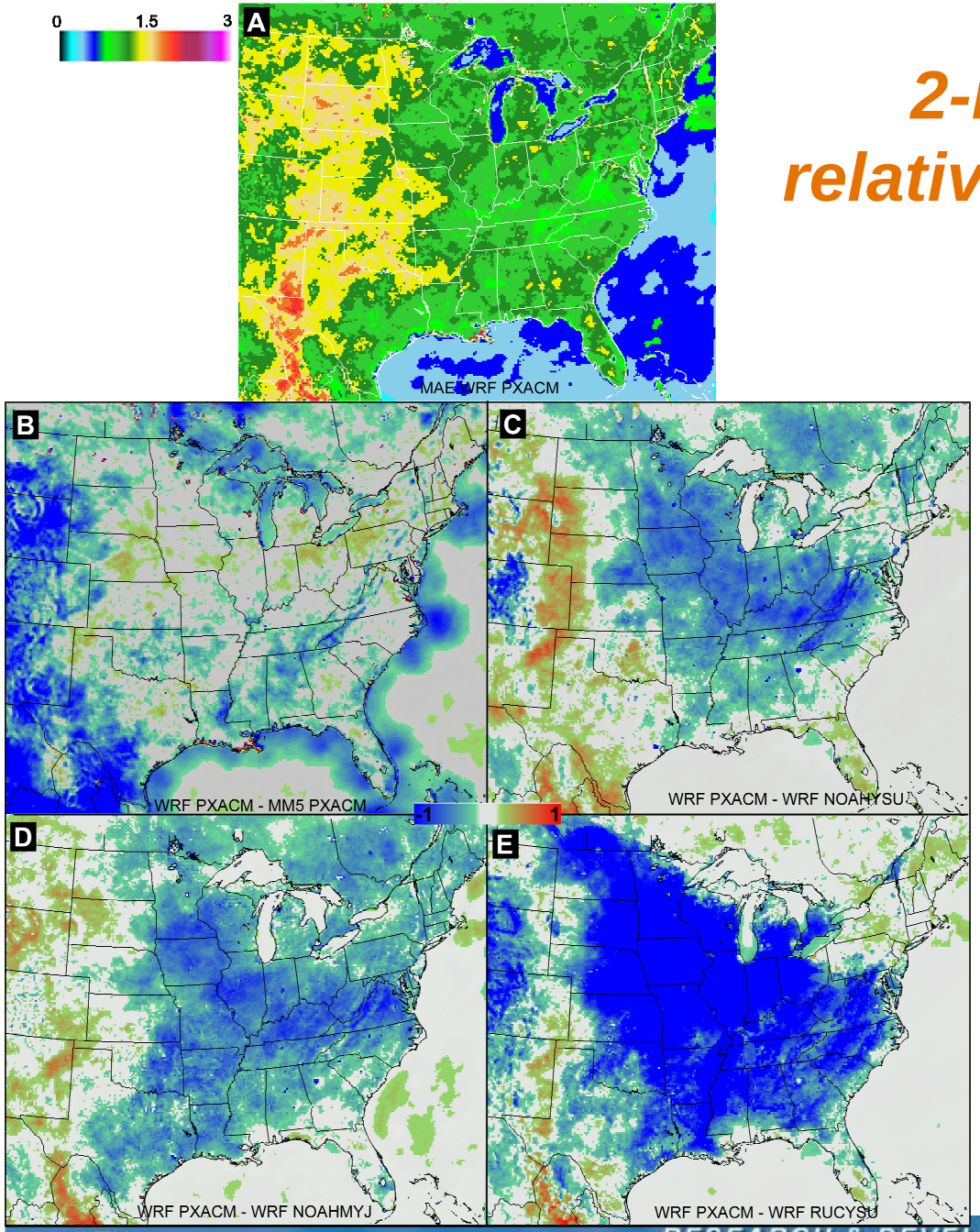
- RMSE of WRF PXACM **minus** other simulations
- 10-m wind analysis not examined
- MM5 PXACM – mixed error difference pattern, more error in WRF PXACM over Plains and Midwest, less in the eastern US and Rockies
- Other WRF simulations have more 10m wind speed error across much of the domain except the parts of the Plains states
- Overall, WRF PXACM has the lower WS error of all simulations

2-m Temperature RMSE (August 2006)



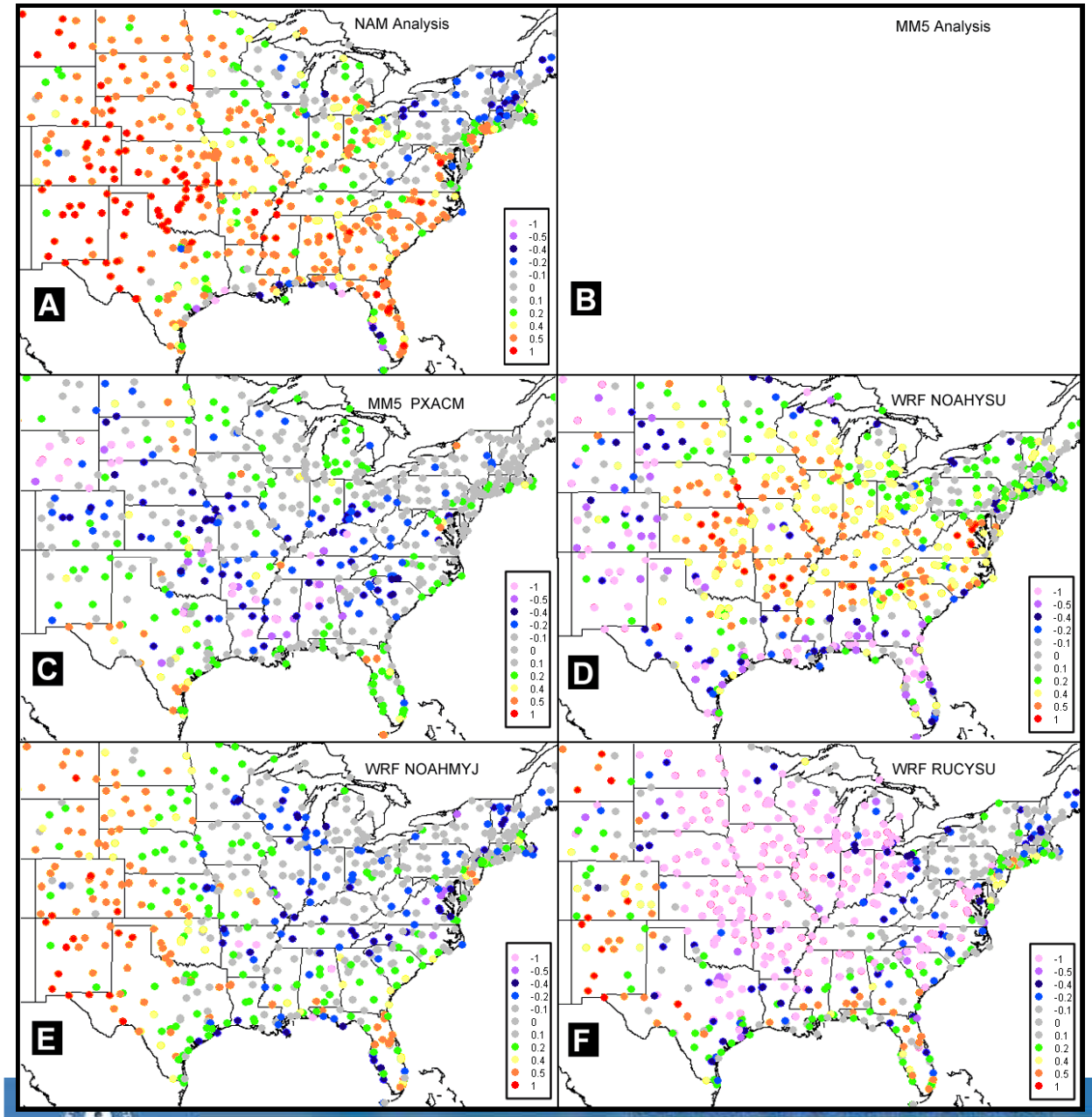
- RMSE of WRF PXACM **minus** other simulations
- WRF PXACM has less error than the NAM analysis in many locations; some areas the NAM has less error
- MM5 analysis has much less error at all locations
- WRF PXACM has less error than MM5 PXACM across the western and central parts of the model domain, more error in the NE US.
- WRF PXACM has much less error than the other WRF simulations over most of the eastern half of the model domain and more error generally over the Rockies

2-m Temperature MAE relative to analysis (Aug 2006)



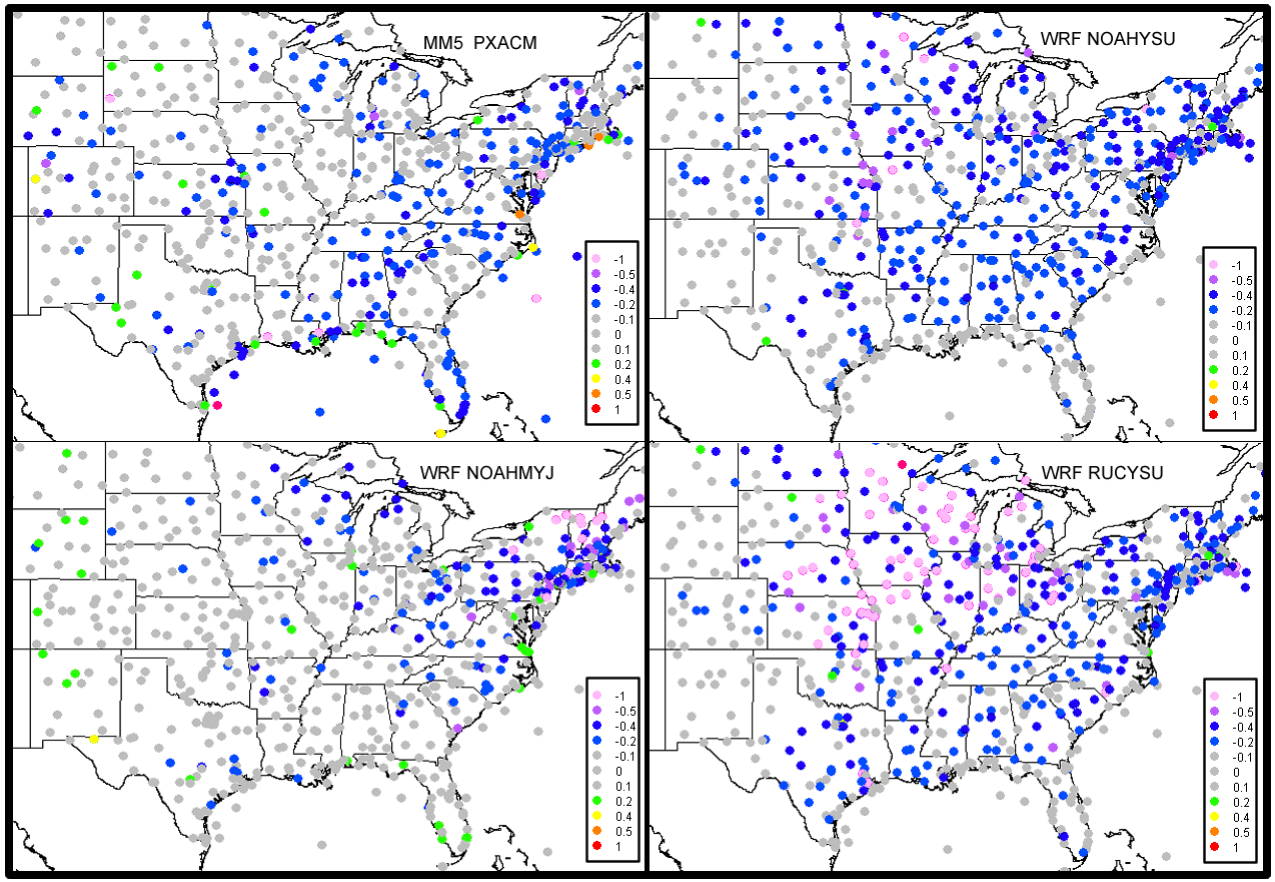
- MAE of WRF PXACM **minus** other simulations
- WRF PXACM has low error over much of the eastern US and Canada and moderate error across the Plains, high plains and Rockies
- MM5 PXACM has less error in a region extended from Nebraska to the Northeast, but more error over the Rockies and southern US
- WRF PXACM has less error than other WRF configurations over the entire eastern US and slightly more error in high plains east of the Rockies

2-m Mixing Ratio RMSE (August 2006)



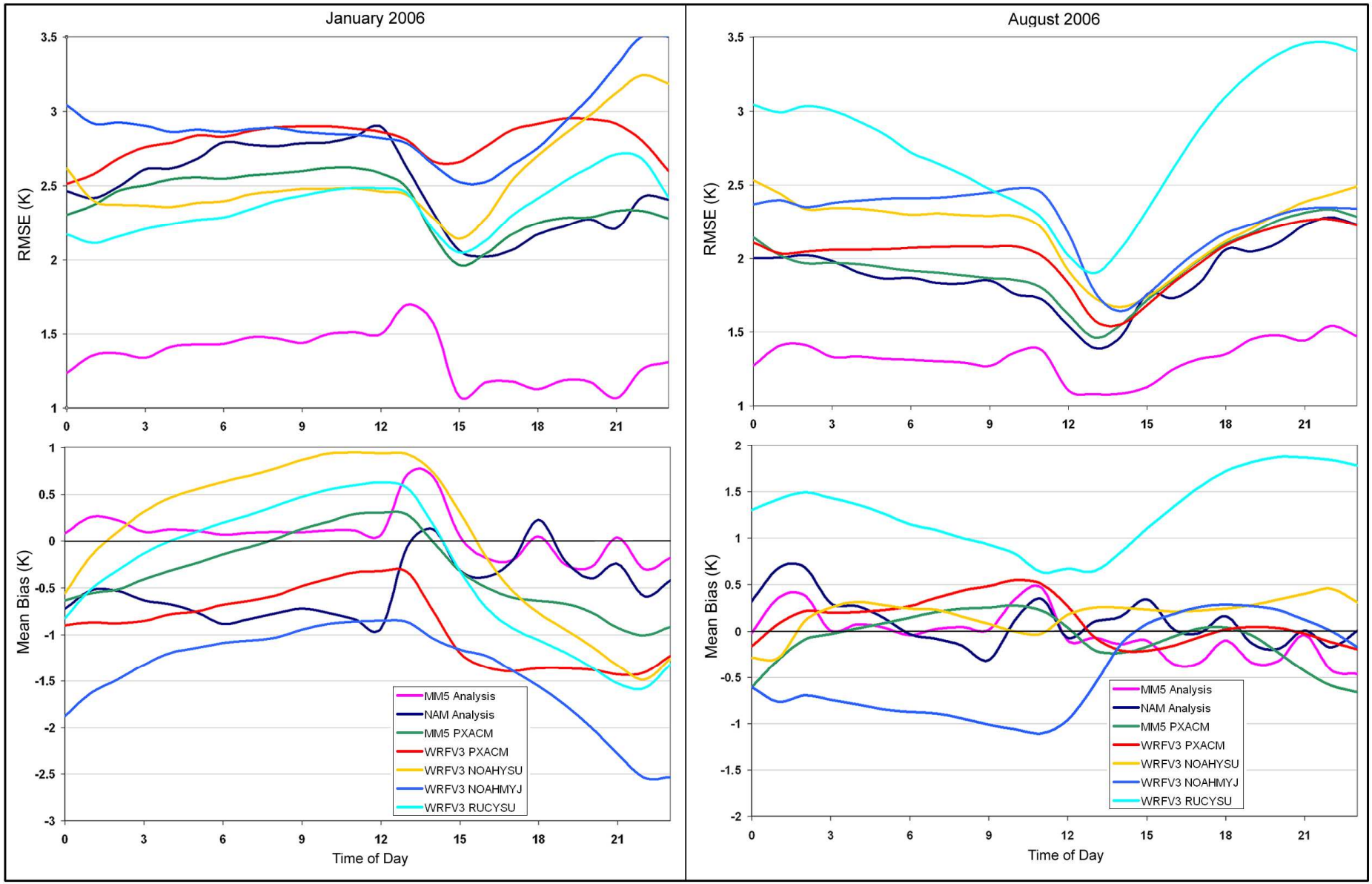
- WRF PXACM RMSE minus other simulations
- NAM analysis has much less error (~ 1 g/kg) than the WRF PXACM in moist climates
- WRF PXACM has less error away from the coasts, MM5 PXACM has less error in marine climates (SE Tx, Fl, E NC)
- WRF NOAHYSU has much less error over much of the central, north and northeast parts of the domain, but WRF PXACM has less error in the west, southwest and southeast parts of the domain. The opposite is true for the WRF NOAHMYJ and RUCYSU

10-m Wind RMSE (August 2006)

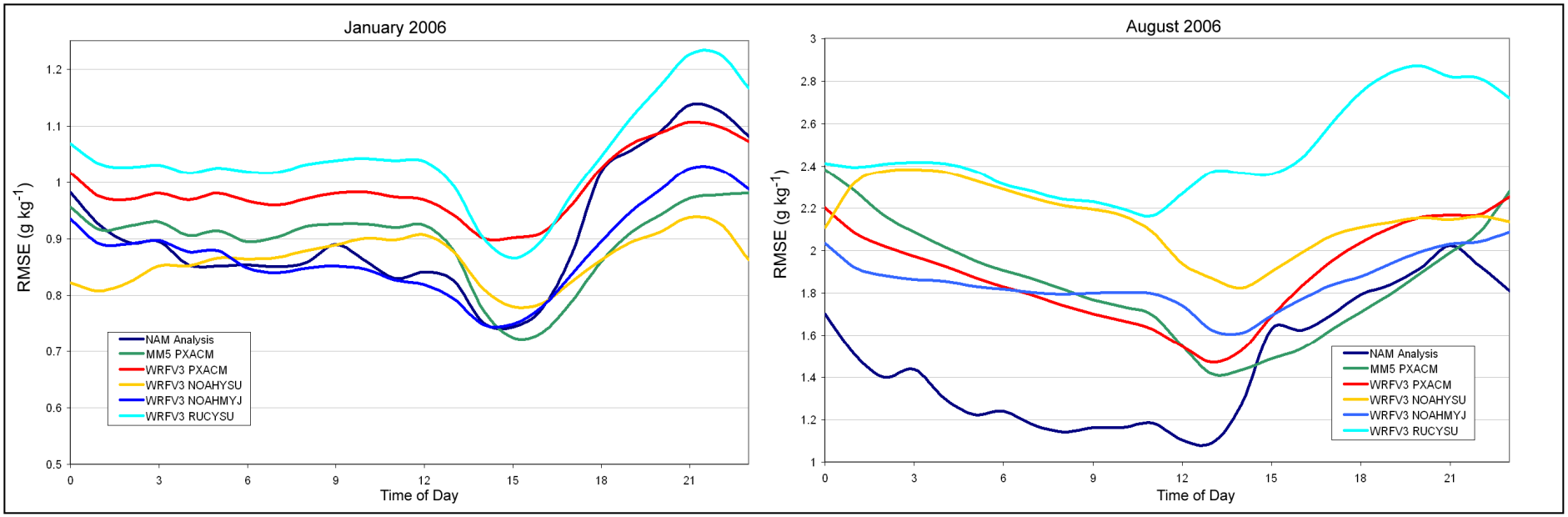


- RMSE of WRF PXACM **minus** other simulations
- WRF PXACM has less error in wind speed than each of the other simulations, especially in the eastern part of the model domain

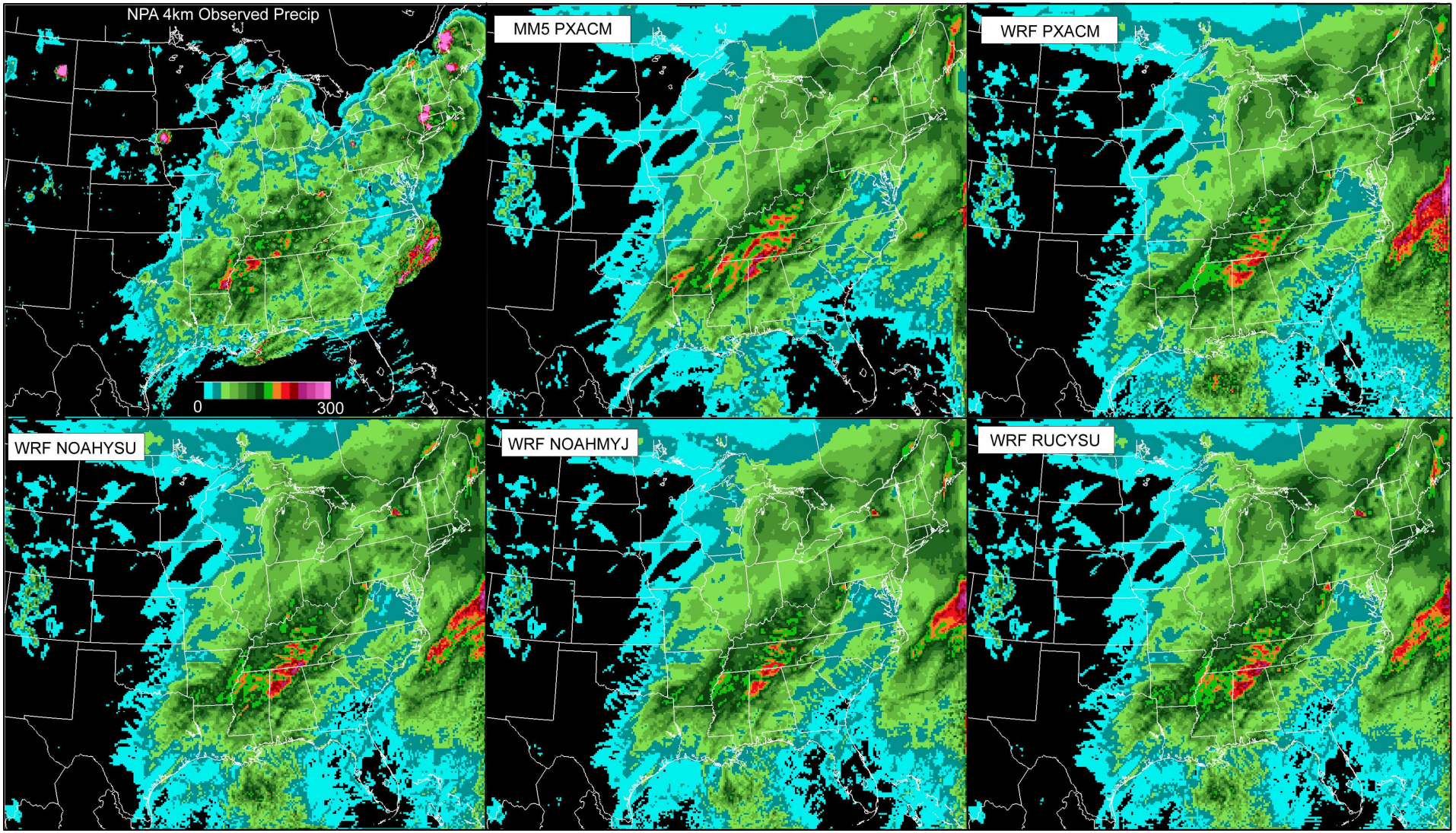
Diurnal 2-m Temperature



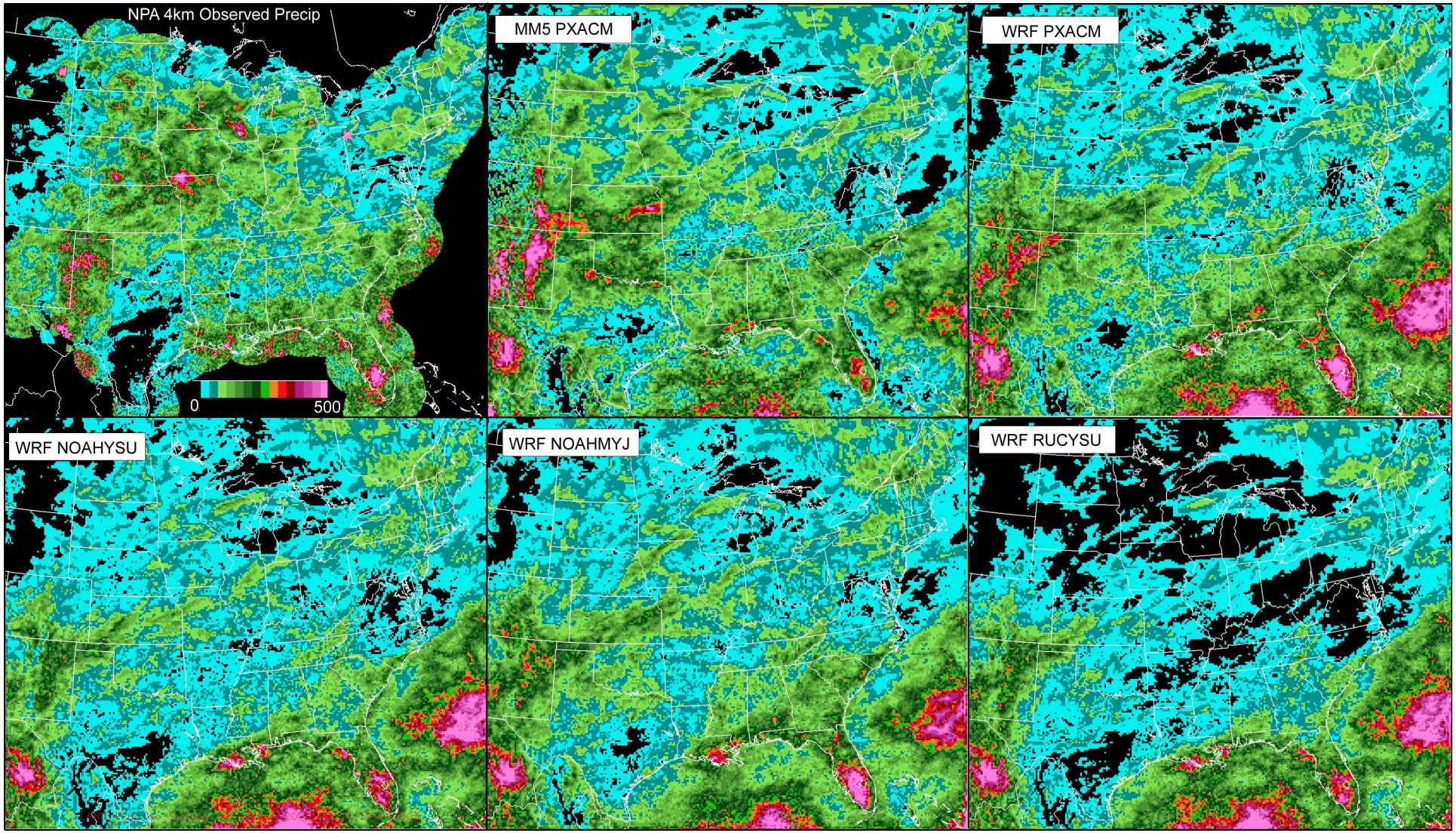
Diurnal 2-m Mixing Ratio



Monthly Precipitation (Jan 2006)

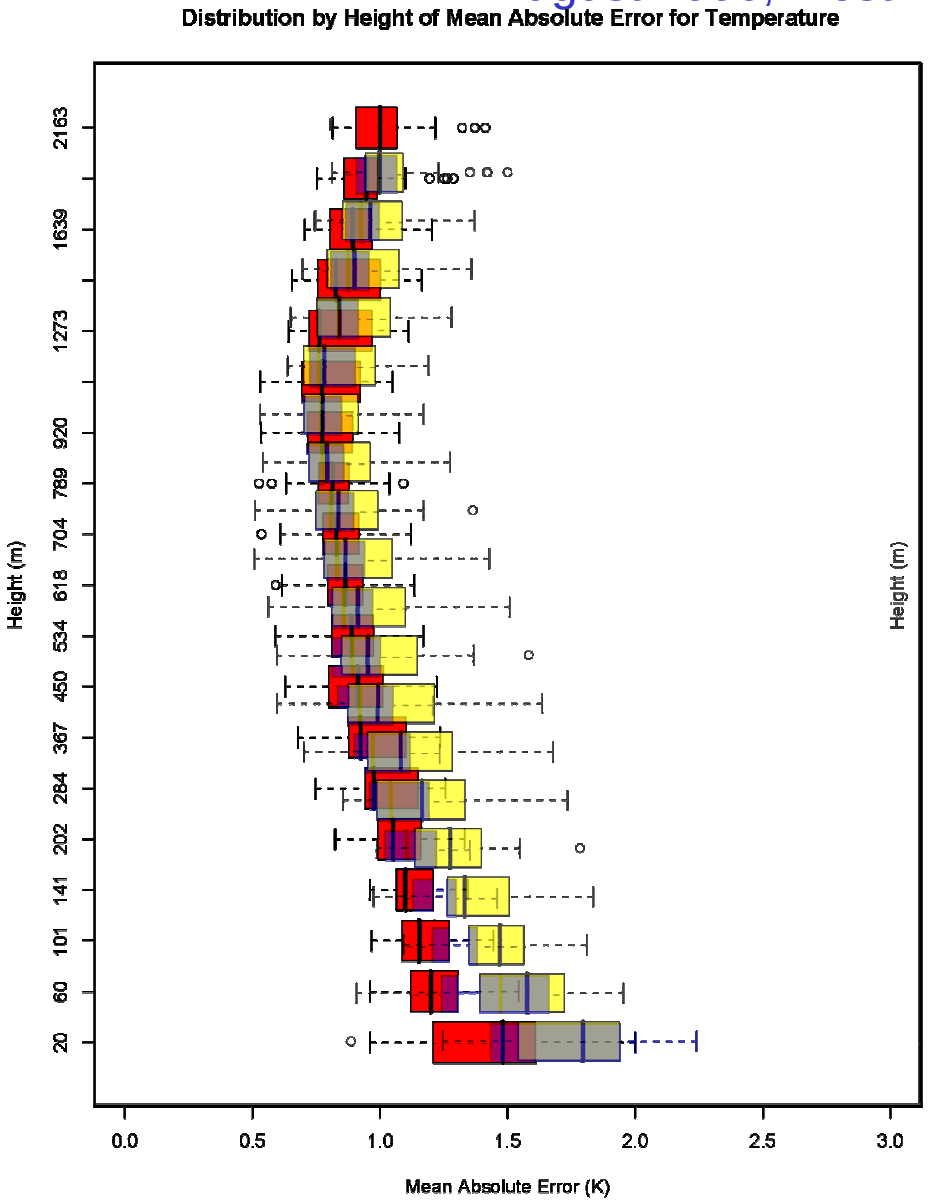


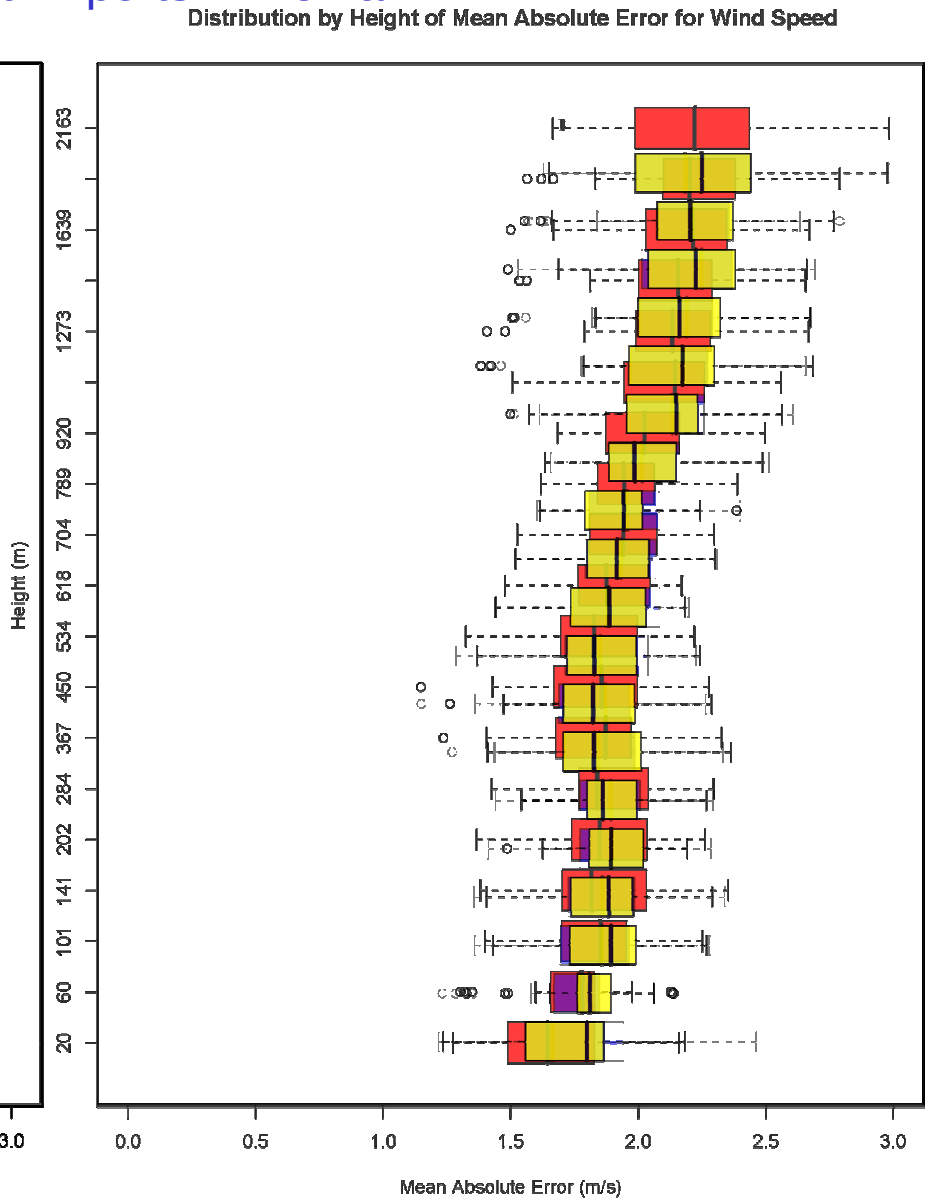
Monthly Precipitation (Aug 2006)



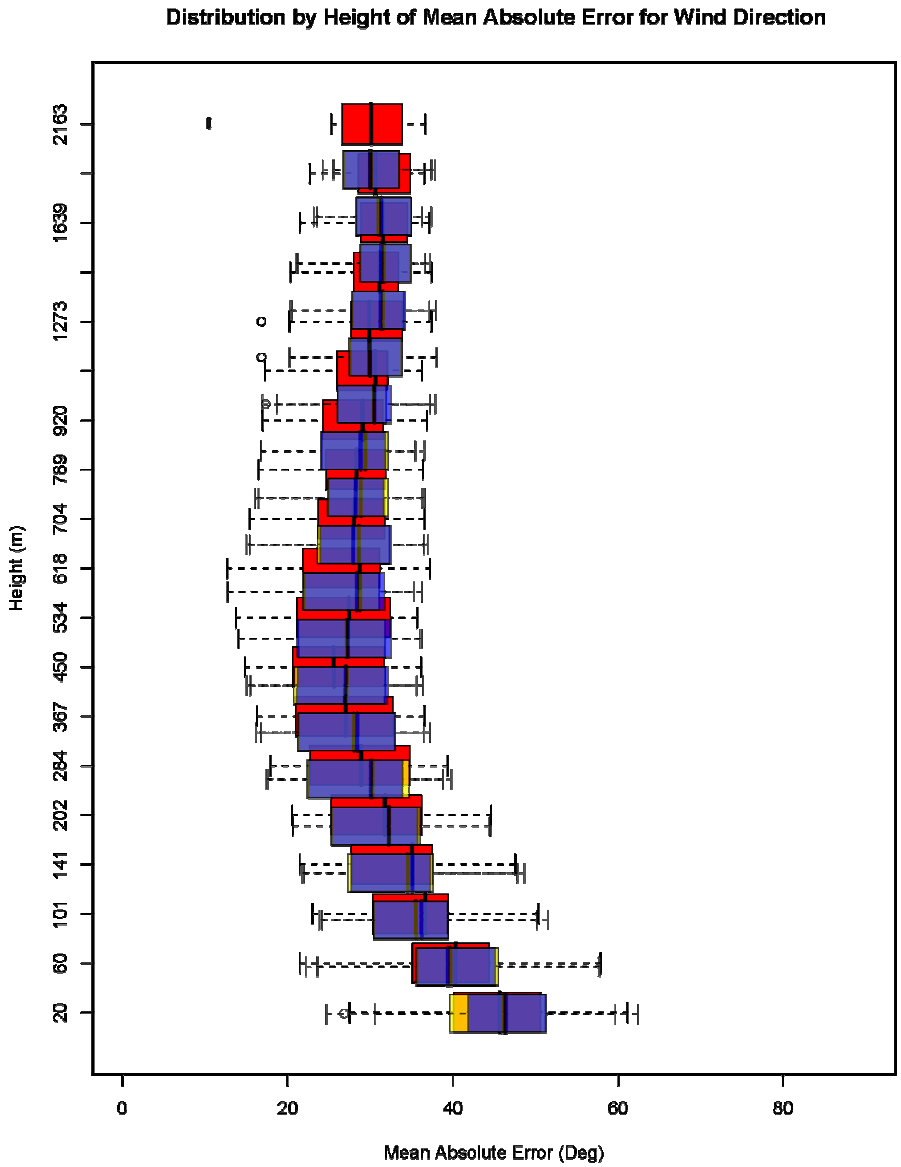
Aircraft Profile – Model Comparisons (Vertical Error Dist)

August 2006, Most Airports in Domain

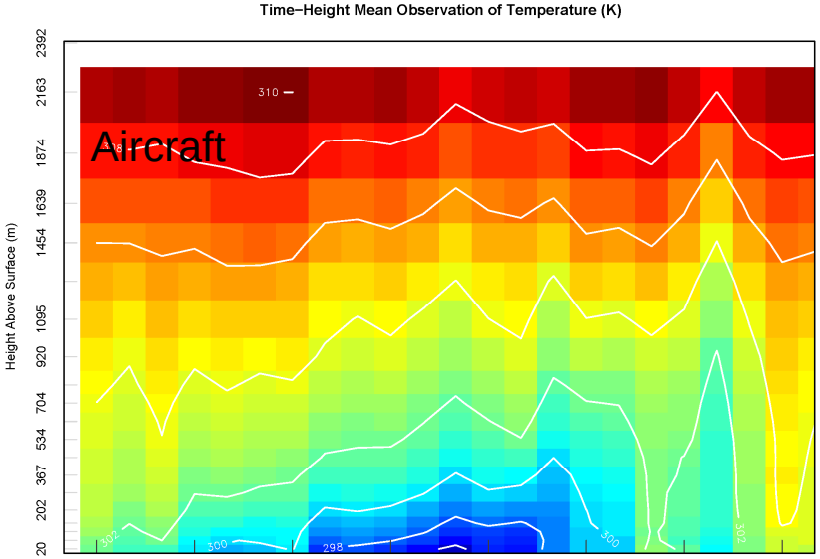


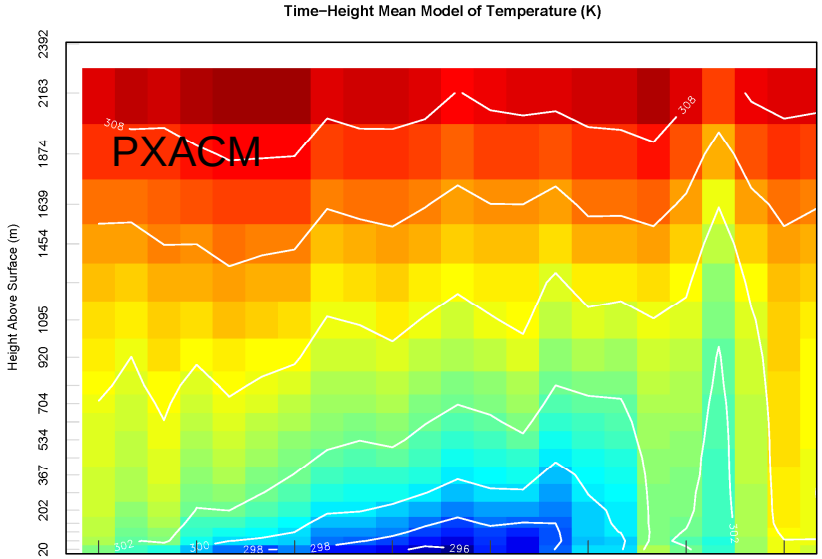


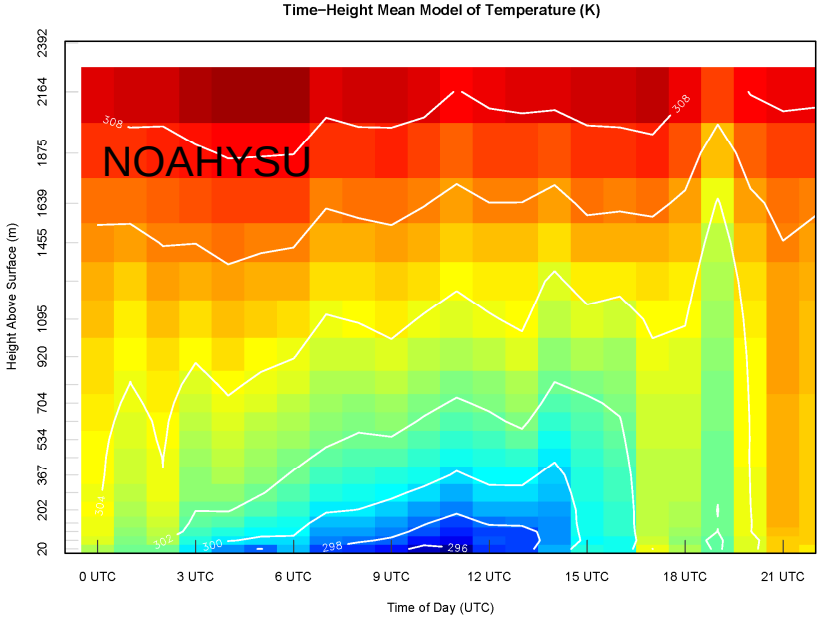
Aircraft Profile – Model Comparisons (Vertical Error Dist)

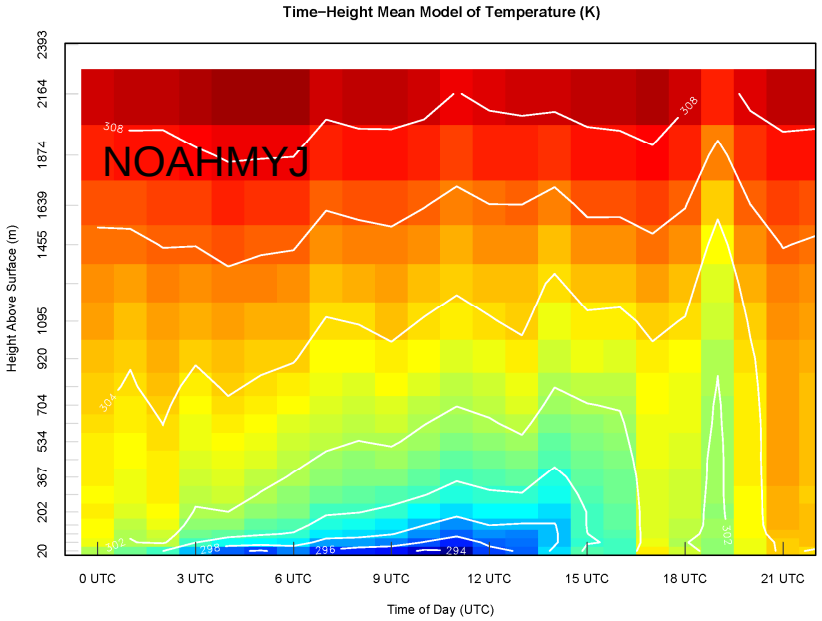


Aircraft Profile – Model Comparisons (Mean PT)

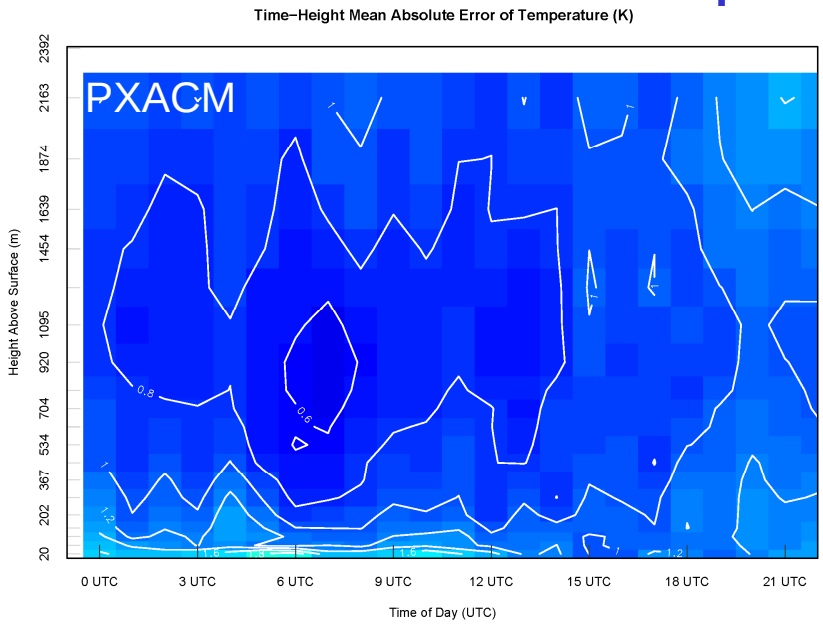


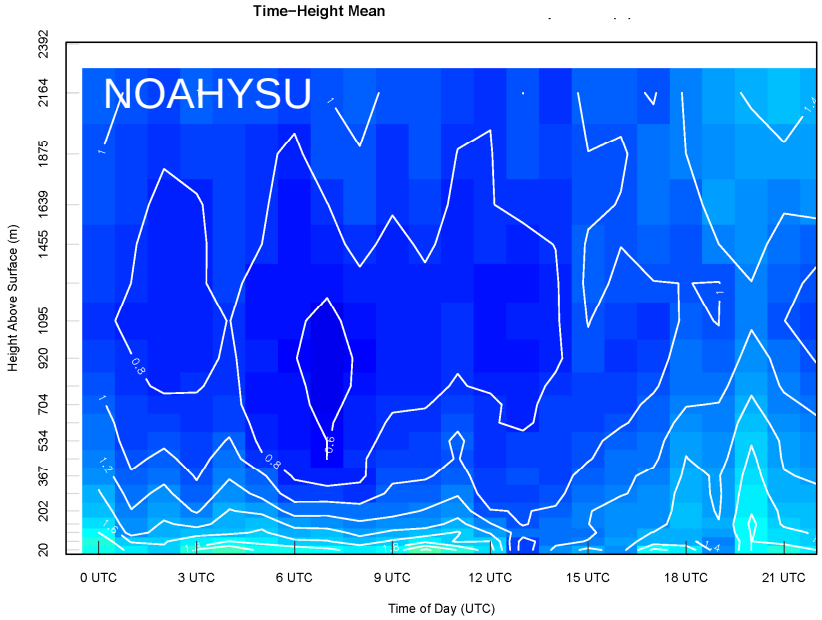


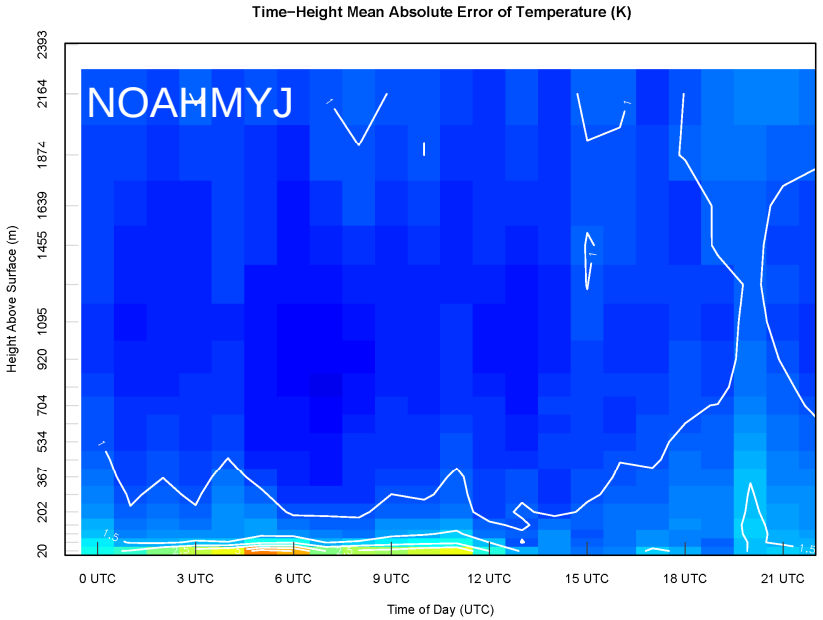




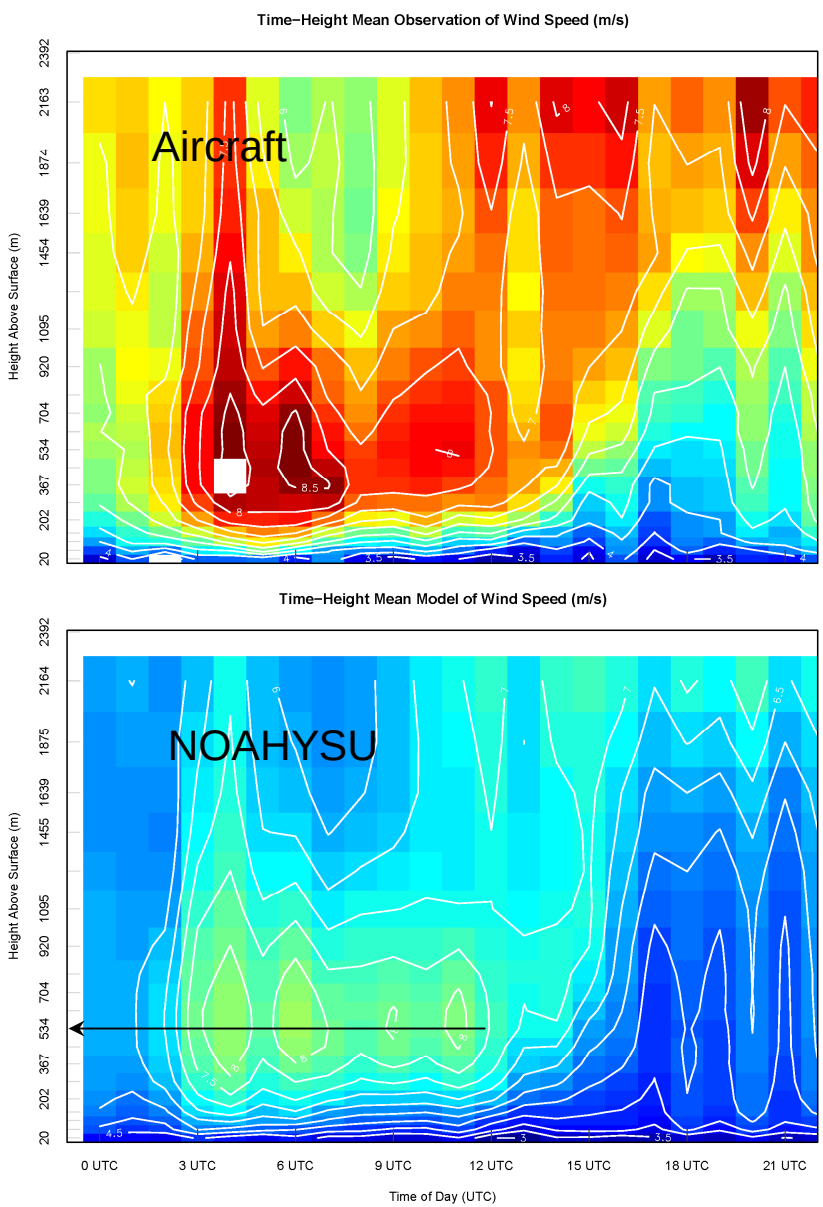
Aircraft Profile – Model Comparisons (MAE PT)

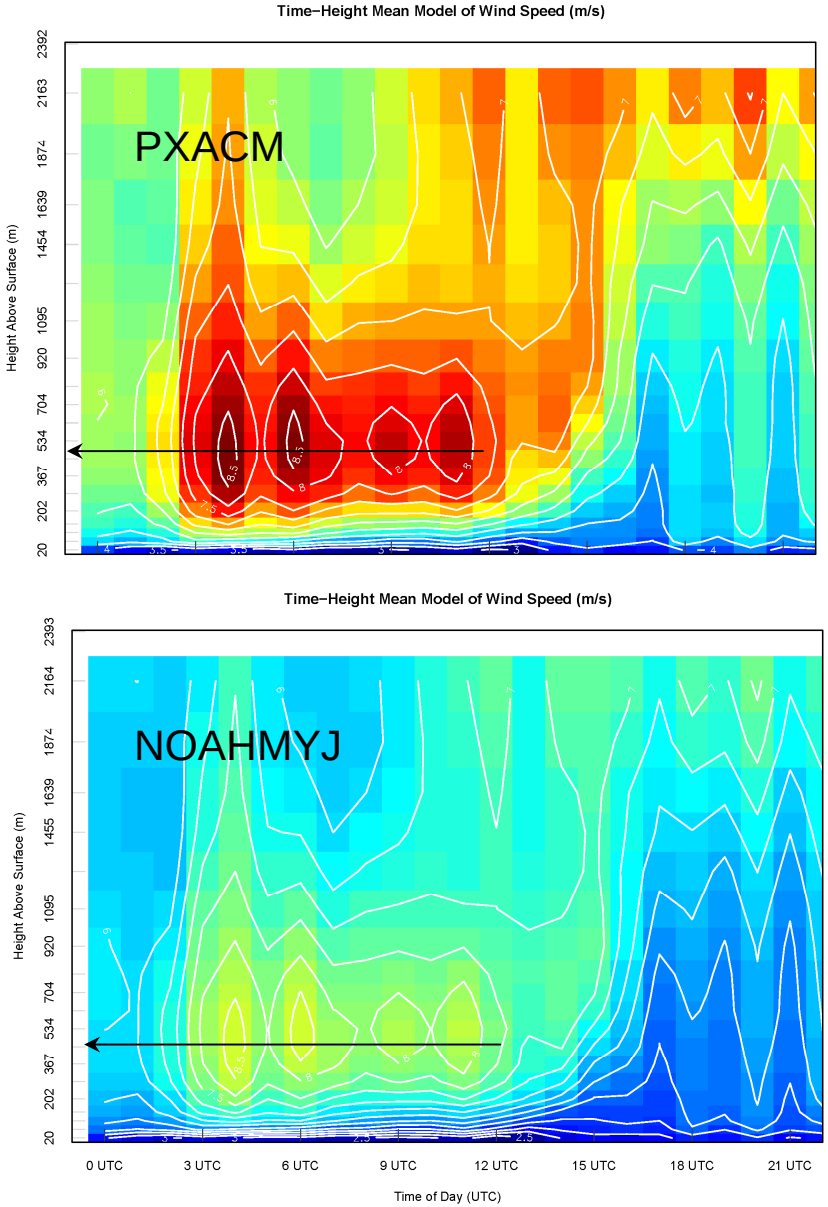




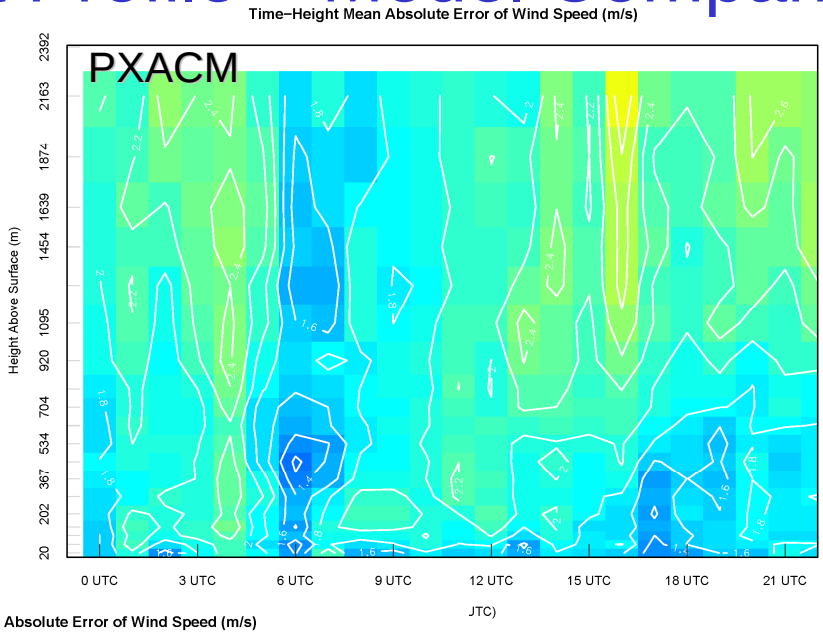


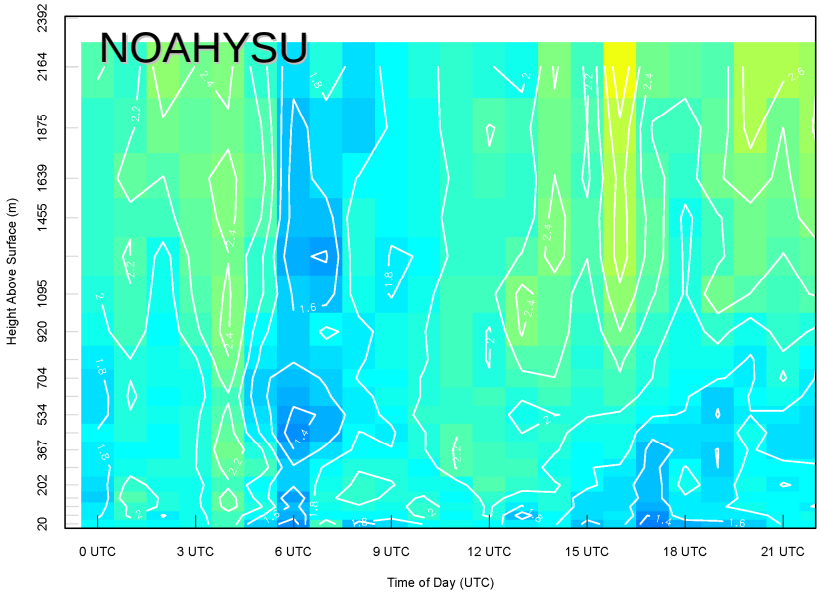
Aircraft Profile – Model Comparisons (Mean WS)

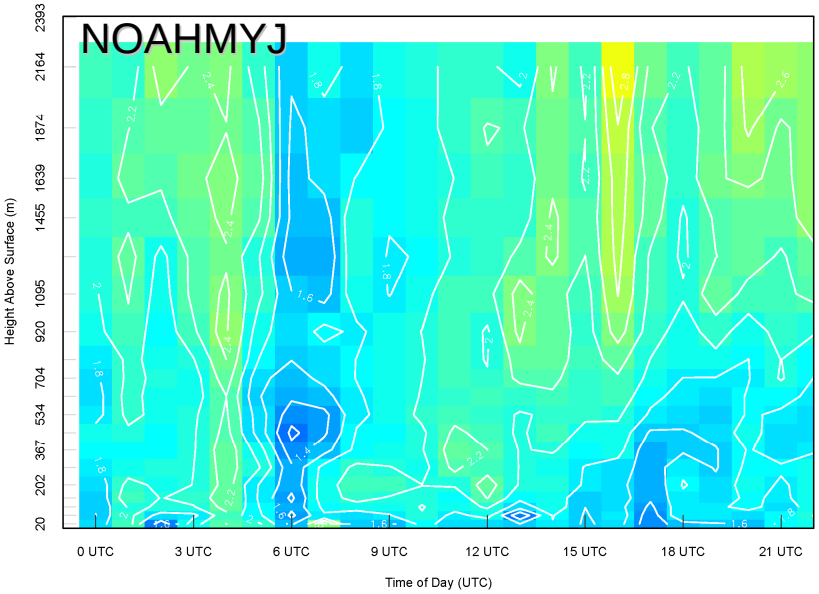




Aircraft Profile – Model Comparisons (MAE WS)







Performance of WRF V3.0

- 2-m temperature is well simulated compared to MM5 and other WRF configurations in summer, but contains more error than the other simulations in winter
- 10-m wind speed error lower (Jan and Aug) in WRF PXACM, even considering all used same wind nudging
- Reasonable estimation of 2-m mixing ratio by WRF PXACM
- Precipitation is well simulated
- Simulated temperature profiles (lower troposphere) contain low error when compared to aircraft data not used in nudging
- Temperature error in lower troposphere contains less error than that at 2-m
- Model simulated boundary layer features like the nocturnal jet and mixed layer evolution with general skill; height of mixed layer overestimated

Future Efforts

- OBSGRID – improved 3-D analyses and surface analyses
- Fine scale (4 and 1 km) modeling protocol (physics, nudging, IC's and BC's)
- NLCD
- Refine snow treatment (snow model)

The End